# Questions and Answers About Bone Marrow Transplantation and Peripheral Blood Stem Cell Transplantation

## 1. What are bone marrow and stem cells?

Bone marrow is the soft, sponge-like material found inside bones. It contains immature cells called stem cells that produce blood cells. There are three types of blood cells: white blood cells, which fight infection; red blood cells, which carry oxygen to and remove waste products from organs and tissues; and platelets, which enable the blood to clot.

Most stem cells are found in the bone marrow, but some stem cells called peripheral blood stem cells (PBSCs) can be found in the bloodstream. Umbilical cord blood also contains stem cells. Stem cells can divide to form more stem cells, or they can mature into white blood cells, red blood cells, or platelets.

## 2. What are bone marrow transplantation and peripheral blood stem cell transplantation?

Bone marrow transplantation (BMT) and peripheral blood stem cell transplantation (PBSCT) are procedures that restore stem cells that have been destroyed by high doses of chemotherapy and/or radiation therapy. There are three types of transplants:

- In **autologous transplants**, patients receive their own stem cells.
- In **syngeneic transplants**, patients receive stem cells from their identical twin.
- In **allogeneic transplants**, patients receive stem cells from someone other than the patient or an identical twin. The patient's brother, sister, or parent may serve as the donor, or a person not related to the patient (an unrelated donor) may be used.

## 3. How are BMT and PBSCT used in cancer treatment?

The main purpose of BMT and PBSCT in cancer treatment is to make it possible for patients to receive very high doses of chemotherapy and/or radiation therapy. To

understand more about why BMT and PBSCT are used and how they work, it is helpful to understand how chemotherapy and radiation therapy work.

Chemotherapy and radiation therapy generally affect cells that divide rapidly. They are used to treat cancer because cancer cells divide more often than most healthy cells. However, because bone marrow cells also divide frequently, high-dose treatments can severely damage or destroy the patient's bone marrow. Without healthy bone marrow, the patient is no longer able to make the blood cells needed to carry oxygen, defend against infection, and prevent bleeding. BMT and PBSCT replace stem cells that were destroyed by treatment. The healthy, transplanted stem cells can restore the bone marrow's ability to produce the blood cells the patient needs.

**4. What types of cancer use BMT and PBSCT?**

BMT and PBSCT are most commonly used in the treatment of leukemia and lymphoma. They are also used in the treatment of childhood brain tumors and neuroblastoma (an uncommon cancer that occurs most often in children). Researchers are evaluating BMT and PBSCT in clinical trials (research studies) for the treatment of various types of cancer, including cancers of the breast and ovary; multiple myeloma; and Wilms' tumor (a type of kidney cancer that occurs in young children). BMT and PBSCT are often used to treat leukemia that is in remission (the signs and symptoms of cancer have disappeared) and cancers that are not responding to other treatment or have recurred (come back).

**5. How is the donor's marrow matched to the patient's marrow in allogeneic or syngeneic transplantation?**

To increase the likelihood of successful transplantation and to minimize potential complications, it is important that the transplanted marrow match the patient's own marrow as closely as possible. People usually have different sets of proteins, called human leukocyte-associated (HLA) antigens, on the surface of their cells. The set of proteins, called the HLA type, is identified by a special blood test.

The success of allogeneic transplantation depends largely on how well the HLA antigens of the donor's marrow match those of the recipient's marrow. The higher the number of matching HLA antigens, the greater the chance that the patient's body will accept the donor's bone marrow.

Close relatives, especially brothers and sisters, are more likely than unrelated people to have HLA-matched bone marrow. However, only 30 to 40 percent of patients have an HLA-matched sibling or parent. The chances of obtaining HLA-matched marrow from an unrelated donor are small, but there has been an increase in the use of marrow from unrelated donors in recent years.

Since identical twins represent a small number of all births, syngeneic transplantation is rare. But because identical twins have the same genes, they also have the same set of HLA antigens. As a result, the patient's body usually accepts the transplant.

**6. How is bone marrow obtained for transplantation?**

In general, the procedure for obtaining bone marrow, which is also called "harvesting," is similar for all three types of BMTs (autologous, syngeneic, and allogeneic). The donor is given either general anesthesia, which puts the person to sleep during the procedure, or local anesthesia, which causes loss of feeling in the area of the body where the bone marrow will be removed. Usually, several small cuts (not requiring stitches) are made in the skin over the pelvic (hip) bone or, in rare cases, the sternum (breastbone). A large needle is inserted through the cuts and into the bone marrow to draw the marrow out of the bone. The process of obtaining the marrow takes about an hour.

The harvested bone marrow is then processed to remove blood and bone fragments. Harvested bone marrow can be combined with a preservative and placed in a liquid nitrogen freezer to keep the stem cells alive until they are needed. This technique is known as cryopreservation. Stem cells may be cryopreserved for many years.

**7. How are PBSCs obtained for transplantation?**

A process called apheresis or leukapheresis is used to obtain peripheral blood stem cells for transplantation. For 4 or 5 days before apheresis, the patient may be given a medication to increase the number of stem cells released into the bloodstream. In apheresis, blood is removed through a central venous catheter (a flexible tube that is placed in a large vein in the neck or chest area). A needle placed in a large vein in an arm can also be used. The blood goes through a machine that removes the stem cells. The blood is then returned to the patient and the collected cells are stored. Apheresis typically takes 4 to 5 hours to complete. The collected cells may be treated with drugs to destroy any cancer cells that may be present (see question 13). The stem cells are then frozen until they are transplanted back to the patient.

**8. Are there any risks associated with donating bone marrow?**

Because only a small amount of bone marrow is removed, donating usually does not pose any significant problems for the donor. The most serious risk associated with donating bone marrow involves the use of anesthesia during the procedure.

Within a few weeks, the donor's body will have replaced the donated marrow. The area where the bone marrow was taken out may feel sore for a few days, and the donor may feel tired. The time required for a donor to recover varies. Some people are back to their usual routine within 2 or 3 days, while others may take up to 3 to 4 weeks to recover their strength.

**9. Are there any risks associated with donating PBSCs?**

Apheresis is usually painless and causes minimal discomfort. During apheresis, the person may feel lightheadedness, chills, numbness around the lips, and cramping in the hands. Unlike bone marrow donation, PBSC donation does not require anesthesia. The medication that is given to stimulate the release of stem cells from the marrow into the bloodstream may cause bone and muscle aches, headaches, and/or difficulty sleeping. These side effects generally stop within 2 to 3 days of the last dose of the medication.

**10. How does the patient receive the bone marrow or PBSCs during the transplant?**

After being treated with high-dose anticancer drugs and/or radiation, the patient receives the bone marrow or PBSCs through a central venous catheter, a flexible tube that is placed in a large vein in the neck or chest area. This part of the transplant is called the "rescue process."

**11. Are any special measures taken when the cancer patient is also the donor (autologous transplant)?**

The bone marrow used for autologous transplantation must be relatively free of cancer cells. The harvested marrow is often treated before transplantation with anticancer drugs in a process known as "purging" to get rid of cancer cells. This minimizes the chance of cancer coming back due to transplanting bone marrow that contains undetected cancer cells. Because purging may damage some healthy marrow cells, more marrow is obtained from the patient before the transplant so that enough marrow will remain after purging has been completed.

**12. What happens after the bone marrow or stem cells have been transplanted to the patient?**

After entering the bloodstream, the transplanted cells travel to the bone marrow, where they begin to produce new white blood cells, red blood cells, and platelets in a process known as "engraftment." Engraftment usually occurs within about 2 to 4 weeks after transplantation, and is monitored by checking blood counts on a frequent basis. Complete recovery of immune function takes much longer, however—up to several months for autologous transplant recipients and 1 to 2 years for patients receiving allogeneic or syngeneic transplants. Doctors evaluate the results of various blood tests to confirm that new blood cells are being produced and that the cancer has not returned. Bone marrow aspiration (the removal of a small sample of bone marrow through a needle for examination under a microscope) can also help doctors determine how well the new marrow is working.

## 13. What are the possible side effects of BMT and PBSCT?

The major risk of both treatments is an increased susceptibility to infection and bleeding as a result of the high-dose cancer treatment. Patients who undergo these procedures may experience short-term side effects such as nausea, vomiting, fatigue, loss of appetite, mouth sores, hair loss, and skin reactions. Additionally, patients receiving BMT may experience nausea and vomiting while receiving the transplant, and chills and fever during the first 24 hours after the transplant.

Potential long-term risks include infertility (the inability to produce children); cataracts (clouding of the lens of the eye, which causes loss of vision); secondary (new) cancers; and complications in the liver, kidneys, lungs, and/or heart.

With allogeneic BMT, a complication known as graft-versus-host disease (GVHD) sometimes develops. GVHD occurs when white blood cells from the donor marrow (the graft) identify the cells of the patient's body (the host) as foreign and attack it. GVHD can generally be treated with steroids or another immunosuppressive agent. Clinical trials are being conducted to find ways to prevent GVHD from occurring.

The likelihood and severity of complications are specific to the patient's treatment and should be discussed with the patient's doctor.

## 14. What is a "minitransplant"?

A "minitransplant" is a type of allogeneic transplant that is being studied in clinical trials for the treatment of several types of cancer, including leukemia, lymphoma, multiple myeloma, melanoma, and kidney cancer.

A minitransplant uses lower, less toxic doses of chemotherapy and/or total body irradiation (TBI) (radiation therapy to the entire body) to prepare the patient for an allogeneic transplant. The use of low doses of anticancer drugs and TBI eliminates some, but not all, of the patient's bone marrow. It also reduces the number of cancer cells and suppresses the patient's immune system to prevent rejection of the transplant.

Unlike traditional BMT or PBSCT, bone marrow cells from both the donor and the patient may exist in the patient's body for some time after a minitransplant. Once the bone marrow cells from the donor begin to engraft, they may cause what is called a "graft versus tumor effect" and may work to destroy the cancer cells that were not eliminated by the anticancer drugs and/or TBI. To boost the graft versus tumor effect, the patient may be given an injection of their donor's white blood cells. This procedure is called a "donor lymphocyte infusion."

## 15. How do patients cover the cost of BMT or PBSCT?

Advances in treatment methods, including the use of PBSCT, have reduced the amount of time many patients must spend in the hospital by speeding recovery; this shorter recovery time has brought about a reduction in cost. However, because BMT and PBSCT are complicated technical procedures, they are very expensive. Many health insurance companies cover some of the costs of transplantation for certain types of cancer. Insurers may also cover a portion of the costs if special care is required when the patient returns home.

There are options for relieving the financial burden associated with BMT and PBSCT. A hospital social worker is a valuable resource in planning for these financial needs. Federal Government programs and local service organizations may also be able to help.

The NCI's Cancer Information Service (CIS) can provide patients and their families with additional information about sources of financial assistance (see below).

## 16. Where can people get more information about potential donors and transplant centers?

The National Marrow Donor Program® (NMDP), a Federally funded nonprofit organization, was created to improve the effectiveness of the search for donors. The NMDP maintains an international registry of volunteer potential donors for all sources of blood stem cells used in transplantation: bone marrow, peripheral blood, and umbilical cord blood.

The NMDP has developed a directory of participating transplant centers. Each directory entry includes a description of the center, a summary of the center's areas of expertise, and contact information.

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| **Organization:** | National Marrow Donor Program |
| **Address:** | Suite 500<br>3433 Broadway Street, NE.<br>Minneapolis, MN 55413 |
| **Telephone:** | 612–627–5800<br>1–800–MARROW–2 (1–800–627–7692) |
| **Internet Web site:** | http://www.marrow.org |

## 17. Where can people get more information about clinical trials of BMT and PBSCT?

Clinical trials to evaluate BMT and PBSCT are an appropriate treatment option for certain patients with advanced cancer, cancer that has come back, or cancer that has not responded to standard treatment. Through research, doctors learn new ways to treat cancer that may be more effective than the standard therapy. Information about ongoing clinical trials is available from the Cancer Information Service (see below), or from the

National Cancer Institute's cancerTrials™ Web site at http://cancertrials.nci.nih.gov on the Internet.

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## Sources of National Cancer Institute Information

**Cancer Information Service**

Toll-free: 1–800–4–CANCER (1–800–422–6237)
TTY (for deaf and hard of hearing callers): 1–800–332–8615

**NCI Online**

***Internet***

Use http://cancer.gov to reach NCI's Web site.

***CancerMail Service***

To obtain a contents list, send e-mail to cancermail@icicc.nci.nih.gov with the word "help" in the body of the message.

**CancerFax®** fax on demand service

Dial 301–402–5874 and listen to recorded instructions.

## This fact sheet was reviewed on 8/22/00